Environment, Health and Safety Division
Environmental Services Group

August 31, 2005
ES-05-035

To: Richard DeBusk

From: Mike Ruggieri

Subject: Causal Analysis of 15 Electrical Incidents that Occurred at Berkeley Lab from July 2002 to June 2005

Enclosed please find the final letter report, "Causal Analysis of 15 Electrical Incidents that Occurred at Berkeley Lab from July 2002 to June 2005". In addition, attached is an MS Word table that contains the detail findings from the analysis and a copy of the PowerPoint presentation that was given at the EH&S Town Hall meeting on August 2, 2005.

If you have any questions, my telephone extension is x5440.

cc: P. Pei
J. Chernowski
M. Kotowski
T. Caronna

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

SAAR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
1. SAAR (20024595)	Employee received an electrical shock when she accidentally touched a fuse outlet to a power supply.	7/29/2003	Chemical Sciences Division	Building 2 Room 458	A4-B2-C08; Management Problem, Resource Management LTA, Means not provided for assuring adequate equipment quality, reliability or operability.	Electronics Maintenance Shop released a piece of equipment that was unsafe to use. No written requirements for the inspection of equipment before releasing it for usage. Management of electrical shop was not adequate.
2. SAAR (20024694)	Subcontractor received an electrical shock to his left hand when he was working with an electrical connection.	8/7/2003	EH&S	Building 2, Floor 4	A4-B1-C01; Management Problem, Management Methods LTA; Management policy guidance/expectation not well defined understood or enforced. A4-B1-C03; Management Problem, Management Methods LTA; Management direction created insufficient awareness of impact of actions on safety/reliability.	An individual working for Barton Security Services was asked by EH&S to disassemble an electrical device. EH&S selected a non-qualified worker to perform an electrical task
3. SAAR (20026493)	Employee received an electrical shock when working with an electronic survey and alignment device.	4/29/2004	Engineering	Building 6 Floor 1	A4-B2-C08; Management Problem, Resource Management LTA, Means not provided for assuring adequate equipment quality, reliability or operability.	Device was incorrectly wired and the fabricator of the device was not identified. No written inspection procedure. Management was aware that electrical test device was fabricated in-house.
4. SAAR (20027374)	Employee received an electrical shock when working with a data cabinet that contained a power supply.	8/24/2004	Physical Biosciences	Building 80 Beam Line 503	A4-B2-C08; Management Problem, Resource Management LTA, Means not provided for assuring adequate equipment quality, reliability or operability.	Electronics Maintenance Shop released a piece of equipment that was unsafe to use. No written requirements for the inspection of equipment before releasing it for usage. Management of Electronics Shop was not adequate.

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

SAAR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
5. SAAR (0047719)	Employee received an electrical shock while troubleshooting a computer electronic power supply.	10/10/2004	Engineering	Building 80, Room 137	A3-B3-C06; Human Performance, Knowledge Based Error, Individual underestimated the problem by using past events as basis. A4-B4-C01; Management Problem, Supervisory Methods; Tasks and individual accountability not made clear to worker.	Employee made an error and assumed that previous troubleshooting was safe because an accident had not occurred. Management did not detect and correct the unsafe work patterns of the employee.
6. SAAR (0048189)	Employee received an electrical shock when attempting to turn on a milling machine with a broken switch.	12/22/2004	Engineering	Building 62 milling area	A2-B2-C03; Equipment/Material Problem, Periodic Corrective Maintenance LTA, Corrective maintenance LTA. A4-B2-C08; Management Problem, Resource Management LTA, Means not provided for assuring adequate equipment quality, reliability or operability..	Milling machine is located in satellite shop and it had not been adequately maintained. Lack of maintenance programs at satellite shops. Client divisions frequently lack the funds or expertise to maintain the equipment.
7. SAAR (0048472)	Employee received an electrical shock when handling a submersible well pump	2/3/2005	Facilities	Near Building 52A	A4-B3-C11; Management Problem, Work Organization and Planning, Inadequate work package preparation. A4-B1-C03; Management Problem, Management Methods, Management direction created insufficient awareness of impact of actions on safety/reliability.	Facilities electrician support was not requested through the Work Request Center. Management did not require electrical circuit power verification before working with submersible pump.

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

SAAR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
8. SAAR (0048478)	Employee received an electrical shock when handling a submersible well pump	2/3/2005	EH&S	Near Building 52A	A4-B3-C11; Management Problem, Work Organization and Planning, Inadequate work package preparation.	Facilities electrician support was not requested through the Work Request Center. Management did not require electrical circuit power verification before working with submersible pump.
9. SAAR (0048553)	Employee received an electrical injury while she was checking an electrical connector.	2/15/2005	ALS	Building 6, Beam Line 12.0.2.	A4-B1-C01; Management problems, Management method LTA, Management policy guidance/expectations not well defined, understood or enforced.	Management had no formal process, in addition to mentoring, that would identify training deficiencies for graduate students and post docs.
10. SAAR (0048952)	Employee received an electrical shock while working with a motor drive.	3/30/2005	Engineering	ALS column 24	A4-B3-C03; Management problem, Work organization and planning, Duties not well distributed among personnel. A4-B1-C01; Management Problem, Management Methods, Management policy guidance/expectations not well defined, understood or enforced.	Employee used a risk practice that was outside of his job scope. Employee was not qualified to perform tasks involving an exposed energized electrical system above 50 volts. Management allowed employees to self-define their roles in tasks.

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

OR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
1. OAK-LBL-OPERATIONS-2002-0003	Violation: Contact to 480-Volt Line by Subcontractor Jackhammer	8/6/2002	Facilities	East of Building 70	3B; Personnel error, Procedure not used or used incorrectly. [from old causal analyses tree] That is similar to the current A5-B3-C02; Communication LTA, Written communication not used, not available or inconvenient to use.	Subcontractor excavated beyond the limits of the dig permit.
2. OAK-LBL - OPERATIONS-2003-0001	Penetration of Underground 110-Volt Utility Line Near Bldg 64	8/1/2003	Facilities	East of Building 64	6; Management Problem, Policy not adequately defined, disseminated or enforced. [from old causal analyses tree] This is similar to the current A4-B1-C01; Management Problem, Management Methods, Management policy guidance/expectations not well defined, understood or enforced.	A dig permit was issued for saw cutting of concrete by a subcontractor to an eight inch depth. However, the permit was not consistent with Admin. Procedure ADMN-053 "Locating Utilities in the Field".
3. OAK--LBL-OPERATIONS-2004-0001	Violation of LOTO Procedures at B74	1/13/2004	Facilities	Building 74 Room 177	A3-B1-C03; Human Performance, Skill based error; Incorrect performance due to mental lapse.	Subcontractor did not follow the submitted project safety plan for proper LOTO.
4. OAK--LBL-OPERATIONS-2004-0003	Penetration of Non-Energized Conduit at B76	9/14/2004	Facilities	B76 Room 109	A3-B2-C01; Human performance LTA, Rule based error, Strong Rule incorrectly chosen over other rules A4-B4-C03; Management Problem, Supervisory Methods, Appropriate level of in-task supervision not determined prior to task. A3-B1-C01; Human performance, Skill based error; Check of work was LTA. A4-B5-C01; Management problem, Change management, Problem identification did not identify need for change.	Permitting employee (Facilities) did not indicate on the dig permit that the requesting client intended to deviate from the original work plan. Management supports work environment that routinely requests that dig permits be provided faster than published requirement mandate. Greater supervisor involvement was required regarding review of permit request. Permitting employee incorrectly presumed that he would have an opportunity to review record documents.

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

OR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
5. OAK--LBL-ALS-2005-0001	Beamline 12.0.2 Electrical Shock	2/15/2005	ALS	Building 6 Beamline 12	A4-B1-C01; Management problems, Management method LTA, Management policy guidance/expectations not well defined, understood or enforced.	Management had no formal process, in addition to mentoring, that would identify training deficiencies for graduate students and post docs.
6. OAK--LBL-ENG-2005-0002	Electrical Shock While Taking Voltage Measurements	3/30/2005	Engineering	B6 R1000 Column 24	A4-B3-C03; Management problem, Work organization and planning, Duties not well distributed among personnel. A4-B1-C01; Management problem, Management methods LTA, Management policy guidance/expectations not well defined, understood or enforced.	Employee used a risk practice that was outside of the job scope. Employee was not qualified to perform tasks involving exposed energized electrical circuits above 50 volts. Management allowed employees to self-define their roles in tasks.

Summary of Electrical SAARs/ORs (July 2002 through June 2005)

OR	Description	Date	Division	Incident Location	Root Cause	Supporting Details
7. OAK--LBL-AFRD-2005-0001	Unexpected Discovery of Energized Wires	6/22005	AFRD	Building 58 high voltage pad	A4-B5-C13; Management problem, Change management, Accuracy/effectiveness of change not verified or not validated. A4-B3-C08; Management problem, Work organization and planning, Job scoping did not identify special circumstances and/or conditions. A4-B5-C04; Management problem, Change management, Risks/consequences associated with change not adequately reviewed/assessed. A3-B3-C05; Human performance, Knowledge based error, Incorrect assumption that a correlation existed between two or more facts. A3-B1-C04; Human performance, Skill based error, Infrequently performed steps were performed incorrectly. A3-B1-C03 Human performance, Skill based error, Incorrect performance due to mental lapse. A4-B1-C01 Management problem, Management methods LTA, Management policy guidance/expectations not well defined, understood or enforced.	B58 energized electrical conduit and wiring was not disabled and removed 10 years ago when the electrical transformer was decommissioned. History of site was not considered as a special circumstance in the work planning process. The work crew modified the original scope of work without an accompanying required hazard analysis. Work crew made incorrect assumption and did not verify that the electrical conduits and associated wiring were de-energized. Work crew exceeded their authority to modify the work scope and perform the work. Mechanical Technician returned to the event scene after reporting the incident and touched the electrical conduit. Personnel at the scene did not immediately report the incident to management.

Causal Analysis of 15 Electrical Incidents That Occurred at Berkeley Lab from July 2002 to June 2005

M. Ruggieri, J. Chernowski, T. Caronna and M. Kotowski

Background

In April 2005, the Environmental Health and Safety (EH&S) Division performed a self assessment of the electrical safety program at Berkeley Lab. One of the corrective actions from the self assessment was to perform a causal analysis of electrical incidents that occurred in the recent past. To that end, a project was conducted in June-July 2005 that analyzed the electrical incidents that occurred from July 2002 to June 2005. The project team was comprised of the following participants:

- Mike Ruggieri (On special assignment from the Environmental Services Group to the Occupational Safety Group)
- John Chernowski (Manager of the Laboratory Office of Contract Assurance)
- Tom Caronna (Laboratory Electrical Safety Engineer)
- Matt Kotowski (Senior Safety Engineer)

Methods

For the purpose of this analysis, electrical incidents were defined as electrical shock and near-miss events that generated Supervisor Accident Analysis Reports (SAARs) and/or Occurrence Reports (ORs). During the period of July 2002 to June 2005, 15 electrical incidents were identified which generated 10 SAARs and seven ORs. Two of the incidents involving electrical shocks also required preparation of ORs, consequently, 15 electrical incidents generated 17 total reports. All of the 10 SAARs were first aids. There were no OSHA recordable electrical incidents during that period. First aid SAARs do not require or typically contain root cause analyses, whereas the ORs do require identification of root causes. Accordingly, the team focused most of their effort on reviewing and analyzing the root causes related to the SAARs.

Using the EH&S SAAR and OR databases, the 17 reports were printed out and reviewed by the project team. Using the DOE Causal Analysis Tree (DOE Order 231.1-2) as a framework, on June 29th the project team met, reviewed and discussed each of the SAARs and identified root causes for each event. The ORs were also reviewed, and the documented root causes were determined to be adequate. Some ORs included direct and contributing causes, which were reviewed but not included in this analysis of root causes.

From that meeting, a summary table of the root causes was assembled and distributed for review by the team. On July 11th, the team met again and completed their analyses of the root causes. The root cause table was revised to incorporate the team's findings and the

results were presented to the Director of the EH&S Division on July 12th. See attached Table 1.

The results from the causal analyses were presented at the DOE Operational Awareness Meeting on July 27th and at the EH&S Town Hall Meeting on August 2nd. A subsequent presentation will be made to the Division Safety Coordinators. See attached PowerPoint presentation.

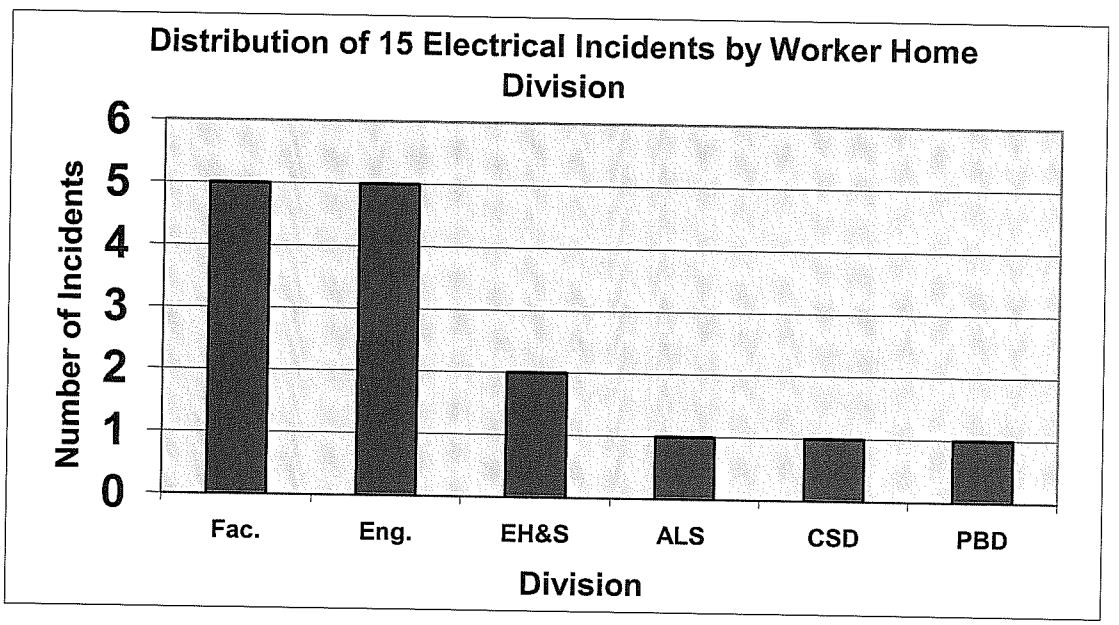
Results

Distribution of incidents by Division

The results of the analyses indicate that six Divisions (out of a total of 17 Divisions at the Lab) generated the 15 electrical incidents; Facilities, Engineering, EH&S, Advanced Light Source (ALS), Chemical Sciences and Physical Biosciences.

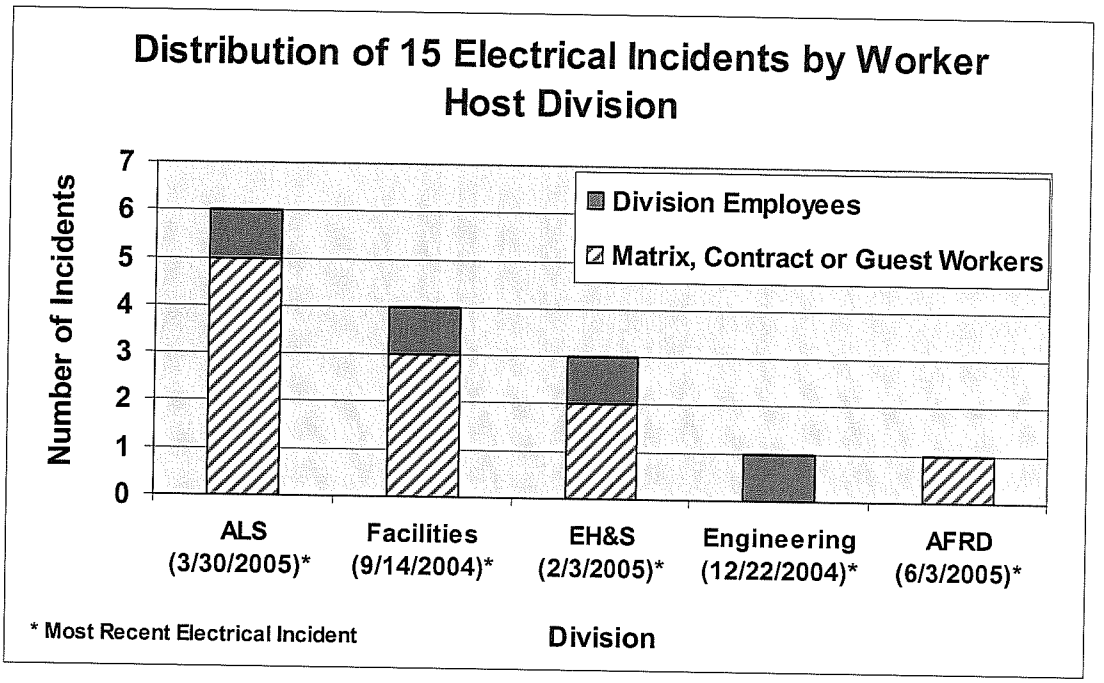
In order to better understand the nature of these electrical incidents, we examined the distribution of the incidents from two perspectives. First we considered the distribution of the incidents based on the worker's home division (See Figure 1).

Figure 1.



Then, we considered the distribution of the incidents based on the worker's host division and separated out host division employees from non-host division employees (matrix, contract and guest workers). Figure 2 shows that data. The two distributions differ significantly. The reason for this is that Divisions such as Engineering provide substantial technical support to host research divisions such as the ALS.

Figure 2.



Distribution of Root Cause Analyses

Using the DOE Causal Analysis Tree, 29 root causes were identified for the 15 incidents. Some root causes were identified multiple times across incidents. For the incidents that required both SAARs and ORs, the root causes were counted only once. See Table 1 (attached) and Figure 3 below. The data shows that 20 of the 29 root causes were due to "management problems", seven were due to human performance, one was due to communication issues and one was due to equipment/material problems. The management problem root causes fell into five subcategories shown in Figure 4. Figure 5 illustrates how the seven human performance root causes were distributed across four subcategories.

Figure 3.

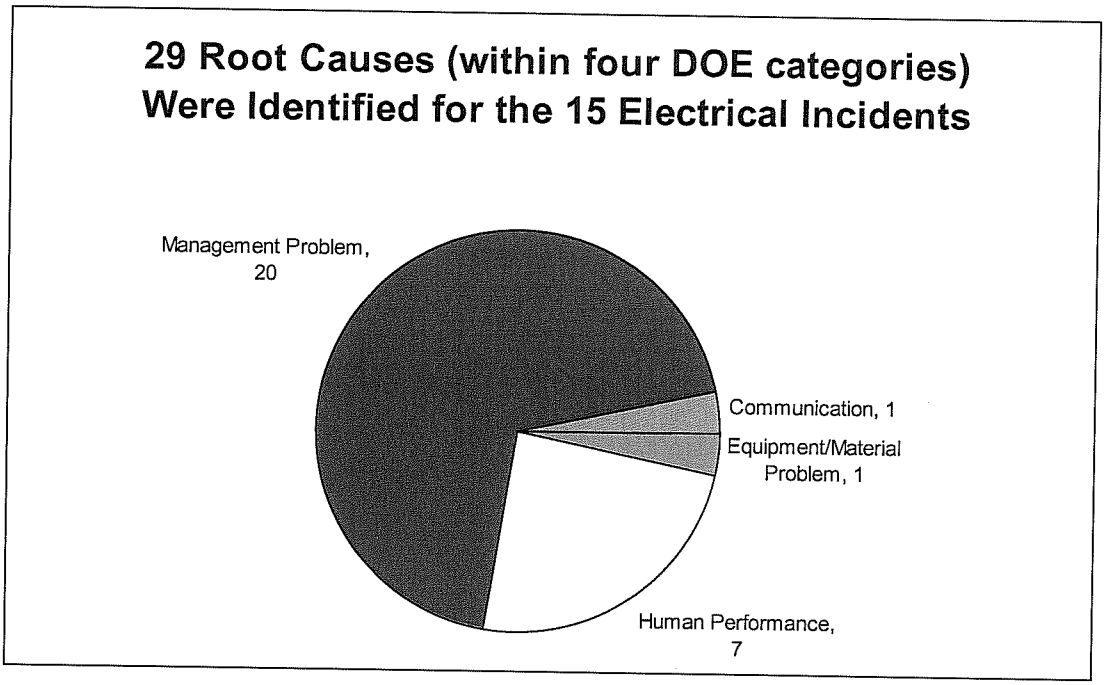


Figure 4.[1]

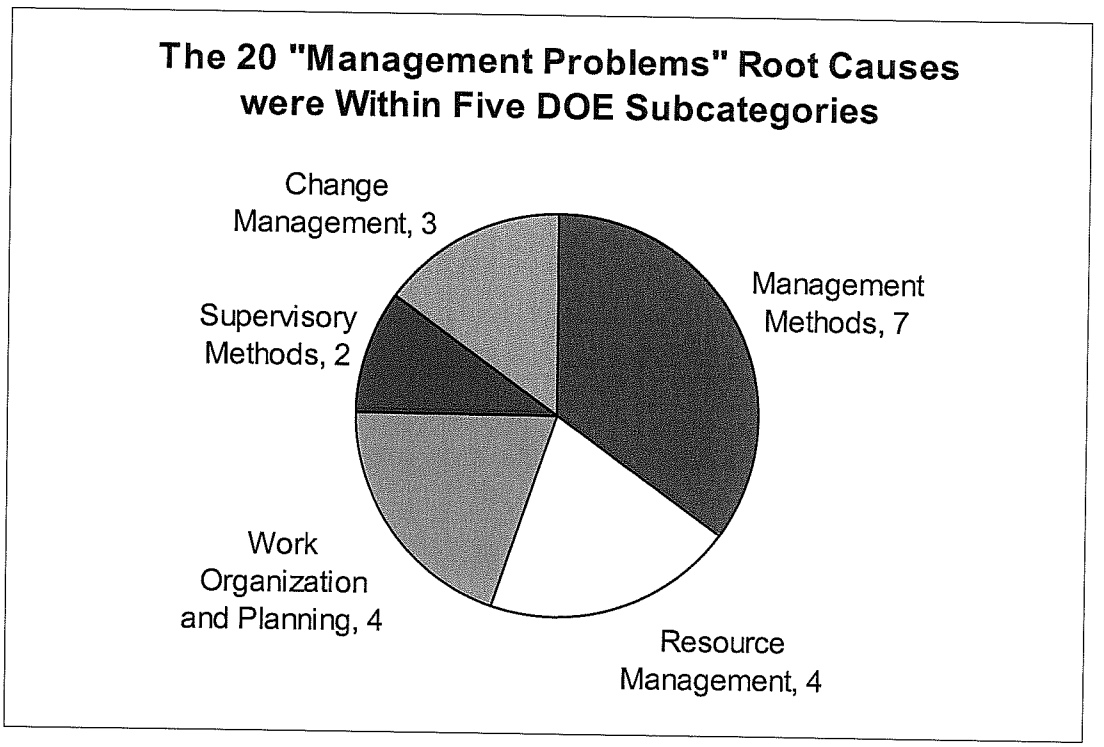
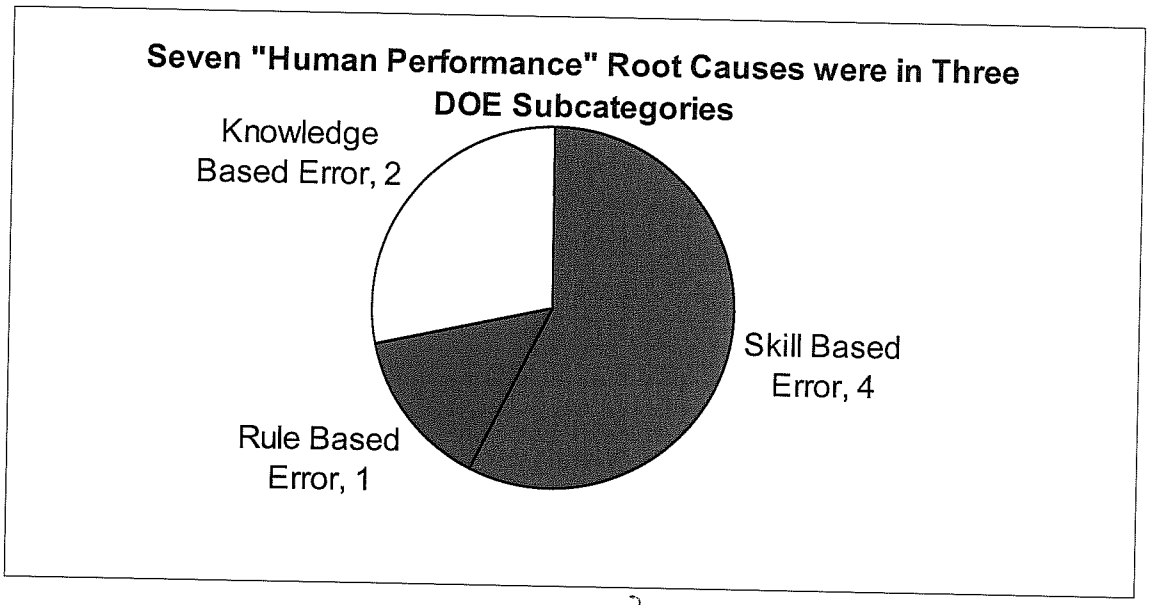


Figure 5.



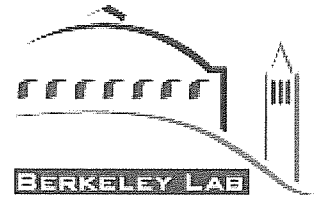
Conclusions

- 11 of the 15 electrical incidents involved workers (matrix employees, contractors, and guests) performing tasks within a host division.
- For seven of the 15 incidents, more than one root cause was identified. This suggests that incident causation frequently involved multiple factors and sources.
- Management problems are the predominant source of root causes (69%) attributed to the 15 incidents that were reviewed. Furthermore, 13 of the incidents included at least one root cause due to management problems.

These findings will be utilized by the Occupational Safety Group to improve the electrical safety program at Berkeley Lab.

1. Figure 4 differs slightly from the equivalent figure in the attached Powerpoint presentation due to an error that was found and corrected while this report was being finalized.

Results From a Causal Analysis of 15 Electrical Incidents at Berkeley Lab (July 2002 – June 2005)



Mike Ruggieri, John Chernowksi*, Tom Caronna and Matt Kotowski

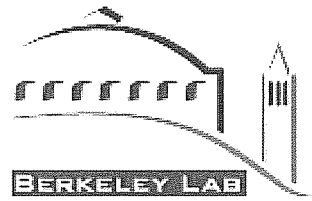
Environment, Health and Safety Division

and

***Laboratory Office of Contract Assurance**

August 2, 2005

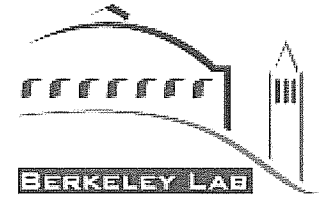
Background and Purpose for the Analysis of Electrical Incidents



- In April 2005, EH&S performed a Laboratory Self Assessment for Electrical Safety and one of the corrective actions was a causal analysis of electrical incidents that occurred in the recent past.

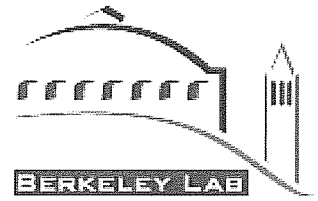
- The analysis identified root causes for each electrical incidents using the DOE Causal Analysis Tree (Rev. 0 DOE M 231.1-2)

Reporting of Electrical Incidents at Berkeley Lab: SAARs and ORs

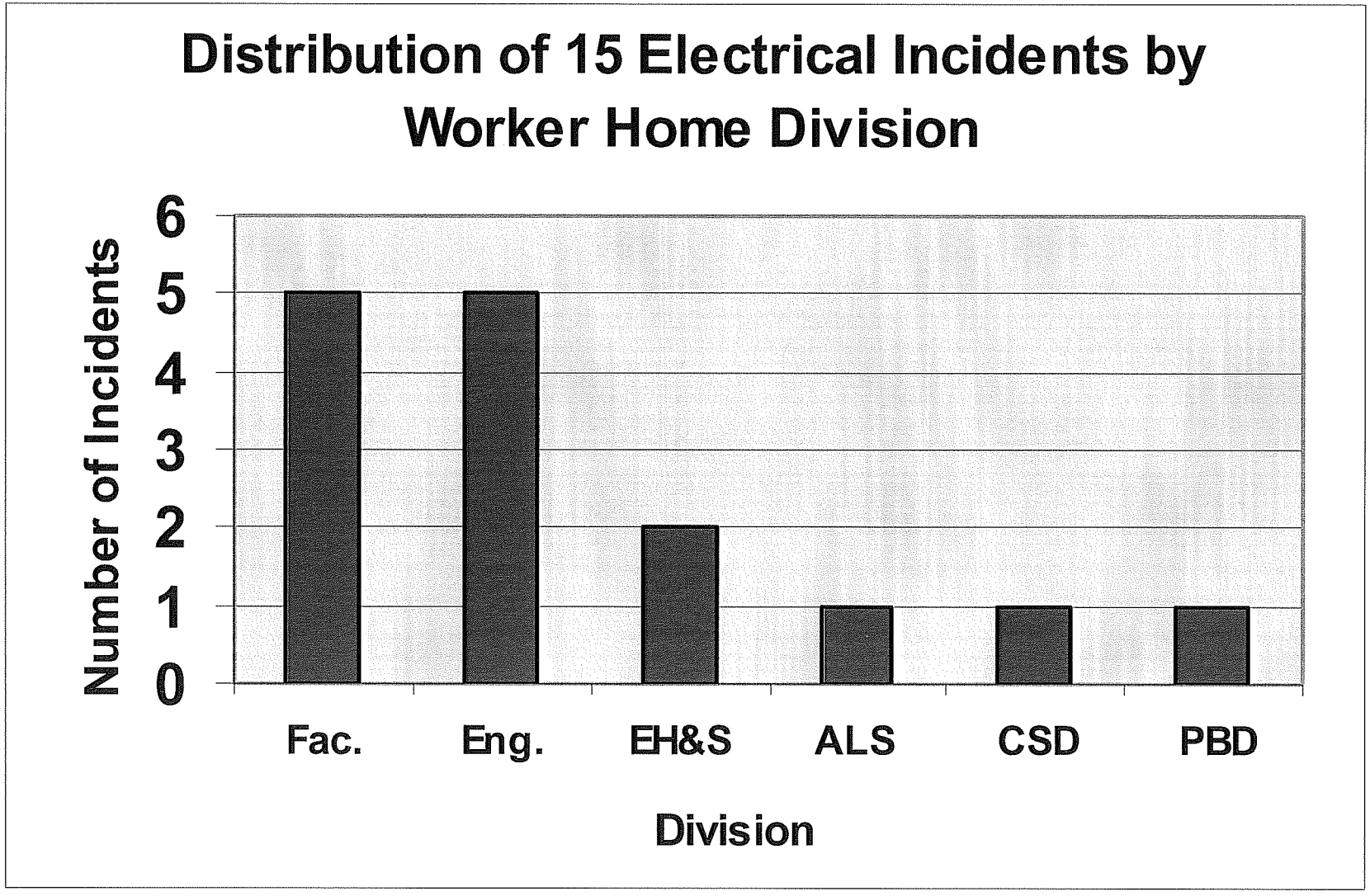


- Following any electrical shock incident, employees are directed to visit Health Services for evaluation and treatment, and a Supervisors Accident Analysis Report (SAAR) is prepared.
  - There were 10 “first aid” SAARs due to electrical incidents in July 2002 - June 2005. No OSHA recordable electrical incidents.
  - There is no minimum electrical shock threshold for a SAAR.
  - Root cause analysis is not required for first aid SAARs.

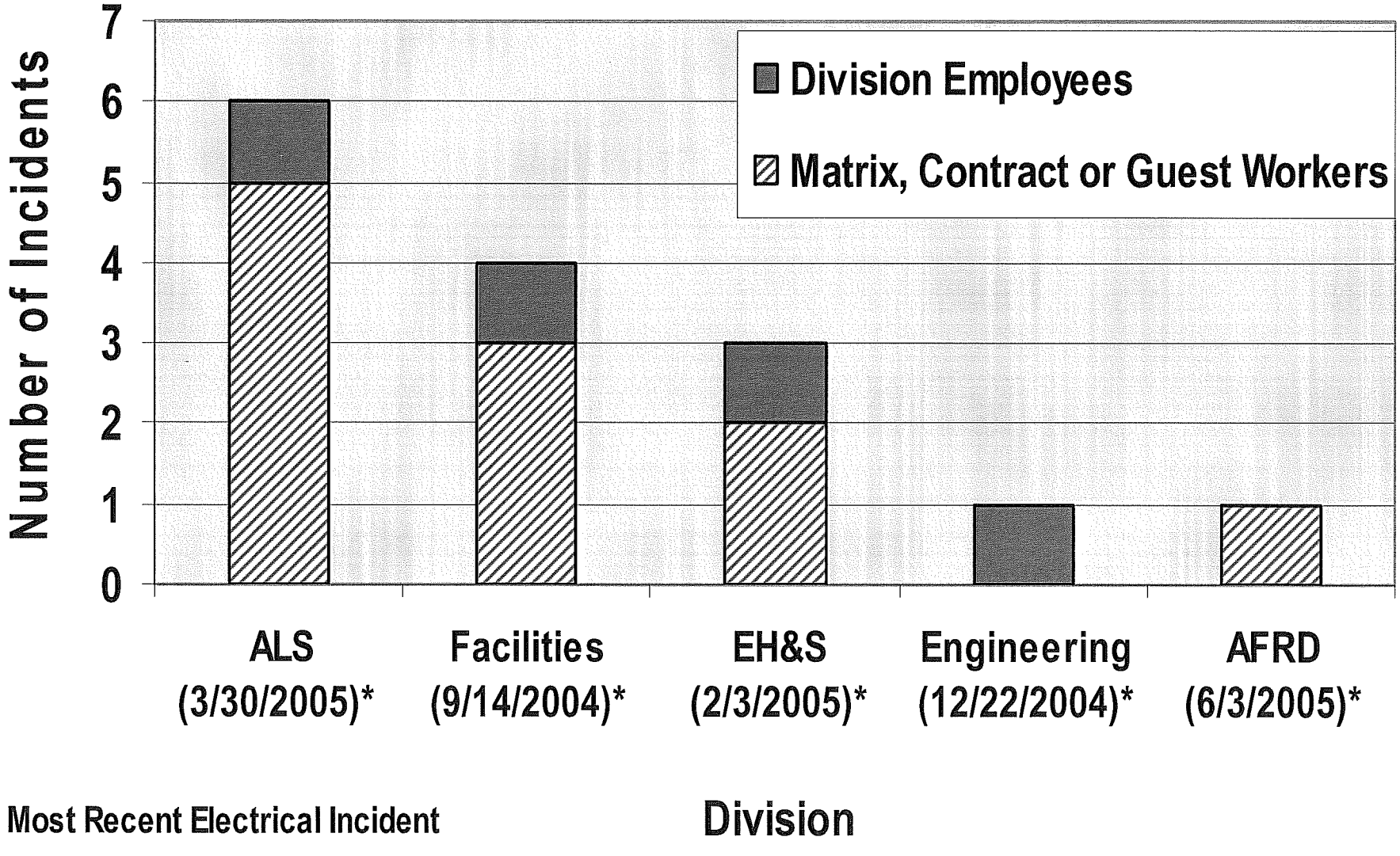
Reporting of Electrical Incidents at Berkeley Lab: SAARs and ORs



- Electrical incidents require the preparation of an Occurrence Report (OR) if the incident meets reporting criteria.
  - There were seven ORs due to electrical incidents in July 2002 – June 2005.
  - Five of the seven OR incidents were electrical shock "near misses".
  - The other two OR incidents involved electrical shocks, which also required SAARs.
  - ORs require root cause analysis.

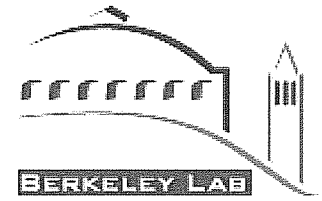

Distribution of 15 Electrical Incidents by Worker Home Division
Number of Incidents
0
1
2
3
4
5
6
Fac.
Eng.
EH&S
ALS
CSD
PBD
Division

Distribution of 15 Electrical Incidents by Worker Host Division



* Most Recent Electrical Incident

Major Categories in the DOE Causal Analysis Tree



A1 Design/Engineering Problem

A2 Equipment/Material Problem

A3 Human Performance Less than Adequate

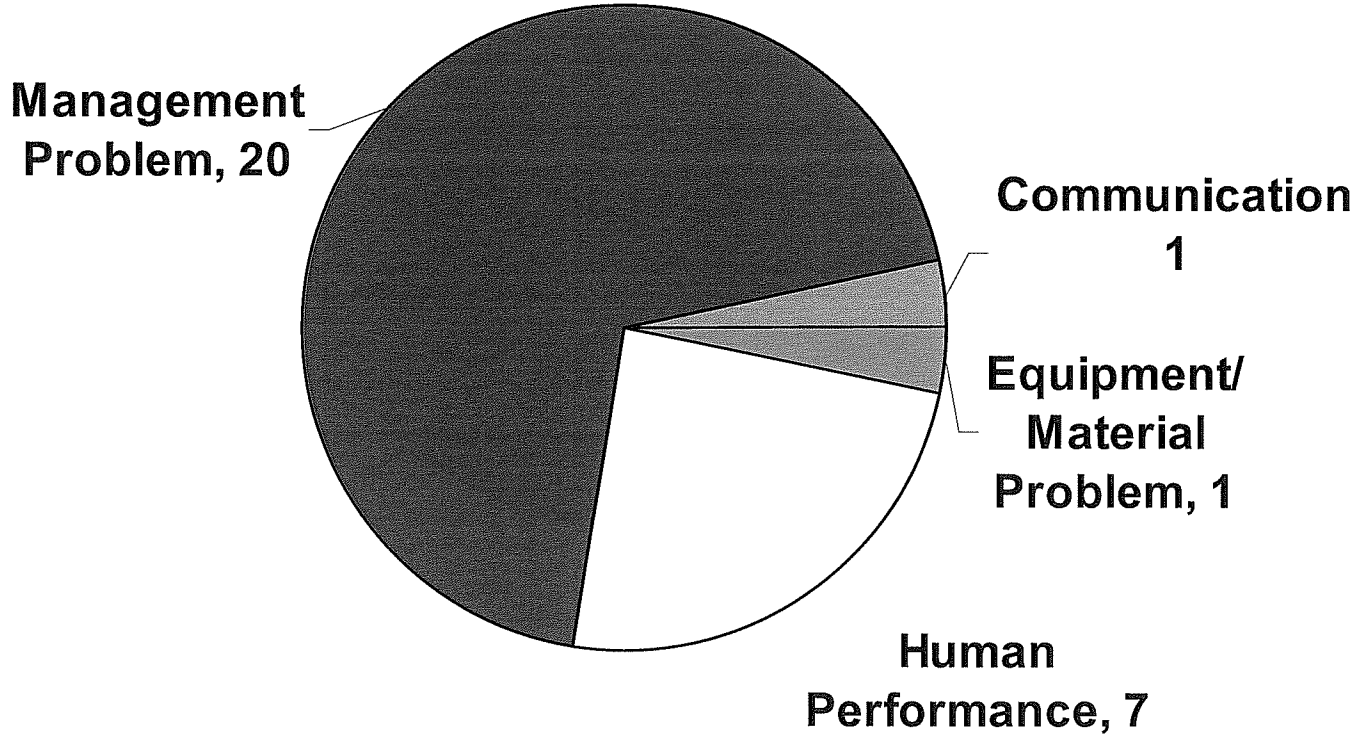
A4 Management Problem

A5 Communication Less than Adequate

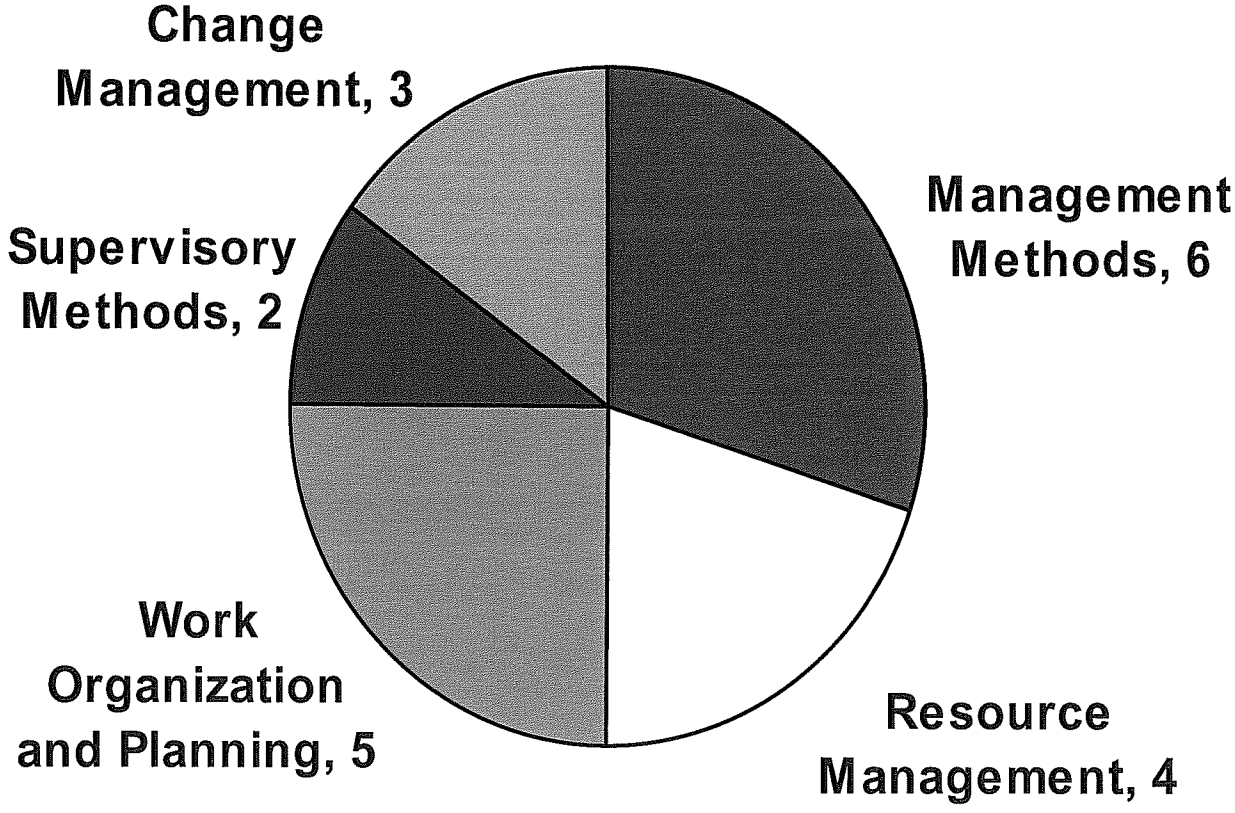
A6 Training Deficiency

A7 Other Problem

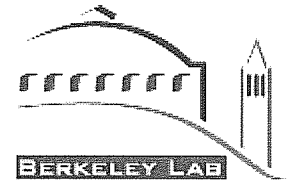
29 Root Causes (within four DOE categories) Were Identified for the 15 Electrical Incidents



The 20 "Management Problem" Root Causes Were Within Five DOE Subcategories

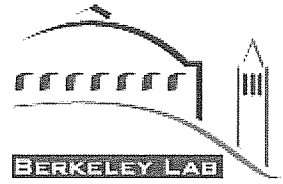


Examples of "Management Problem" Root Causes



Category of Management Problem Root Causes	Observations From the Investigation that Are Evidence of the Root Cause
1. Management Methods	Management lacked a formal process (other than mentoring) to identify training deficiencies for graduate students and post doctorates
2. Resource Management	Management did not require that an electronics shop have written requirements for the inspection of equipment before releasing it to users

Examples of "Management Problem" Root Causes

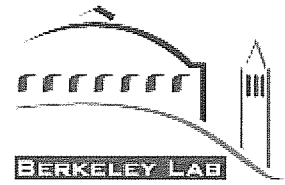


Category of Management Problem Root Causes	Observations From the Investigation that Are Evidence of the Root Cause
3. Work Organization and Planning	Supervisor directed an untrained sub-contractor to disassemble a live electrical device
4. Supervisory Methods	Management supported a work environment that emphasized customer responsiveness and satisfaction at the expense of safety
5. Change Management	A supervised work crew modified an original scope of work without an accompanying hazard analysis

Examples of "Human Performance Problem" Root Causes

Category of Human Performance Root Causes	Observations From the Investigation that Are Evidence of the Root Cause
1.Skill Based Error	Subcontractor did not follow submitted project safety plan for proper lock-out/tag-out.
2.Rule Based Error	Employee did not indicate on permit that the requesting client intended to deviate from the original plan.
3. Knowledge Based Error	Employee made mistake and assumed that previous troubleshooting was safe because an accident had not occurred.

Corrective Actions for Root Causes

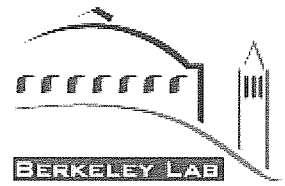


1. **Continually review incidents for trends and patterns**
2. **Revise and clarify electrical safety standards, work permits and train electrical workers**
3. **Hire/Contract Electrical Safety Engineer**
4. **Complete corrective actions for recent DOE electrical safety review**
5. **Revise ground penetration procedures and permits (Facilities – done)**
6. **Survey lockout-tagout (LOTO) practices**
7. **Develop safety management course for PIs, supervisors, managers and mentors**

Corrective Actions for Root Causes

8. **Partner with specific divisions for tailored electrical safety and EH&S programs**
9. **Provide root cause analyses training for Safety Coordinators, EH&S Liaisons and other EH&S staff**
10. **Increase EH&S awareness:**
    - **Improve lessons learned sharing**
    - **Lab Director VIEW articles and emails**
    - **TABL articles**
    - **Safety Spot Award**
    - **Posters (planned)**
11. **Invite Third Party Review for new program ideas to drive next incremental decrease in TRC/DART**

Summary of Results



- **11 of the 15 electrical incidents reviewed involved matrix employees, contractors or guests.**
- **For seven of the 15 incidents, more than one root cause was identified.**
- **Management problems represent the single largest category of root causes for the 15 electrical incidents (20 of the 29 root causes).**
  - **13 of the 15 incidents included at least one root cause due to management problems**